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8630-EN-01

**EVALUATING 1 AND 2D DIMENSIONAL MODELS FOR FLOODPLAIN
INUNDATION MAPPING**

by

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Interim Report 005
December 1999

United States Army

European Research Office of the U.S. Army
London, England

CONTRACT NUMBER N68171-98-M-5830

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Approved for Public Release: distribution unlimited

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Report 005.

For many numerical modelling applications the problem of specifying an optimum mesh resolution remains unbounded and for mesh construction objective a priori rules do not exist. By contrast, the problem of specifying model parameter surfaces is largely bounded within known physical error distributions. In this report we thus investigate the impact of varying mesh resolution (Table 1) on a typical non-linear finite numerical solver. Specifically, a two-dimensional finite element code which solves the Shallow Water equations was used to simulate unsteady flows in a meandering compound channel. A range of different mesh resolutions and parameter surfaces were simulated to determine relative dominance and, unlike previous studies, the effect on both bulk flow (Table 2) and distributed outputs (Table 3) were analysed.

	<i>Mesh 1</i>	<i>Mesh 2</i>	<i>Mesh 3</i>	<i>Mesh 4</i>	<i>Mesh 5</i>	<i>Mesh 6</i>	<i>Mesh 7</i>
<i>No. of nodes</i>	888	1199	1982	2858	3746	4652	6064
<i>% in channel</i>	36.89	35.45	40.26	38.80	33.45	36.86	31.53
<i>No. of elements</i>	1669	2284	3824	5578	7310	9128	11 890
<i>Max.</i>	2607.51	2551.36	1987.42	2528.80	1136.02	1593.97	676.51
<i>Min.</i>	37.04	20.83	11.11	7.41	6.17	4.63	3.97
<i>Avg.</i>	71.54	58.73	43.33	32.24	30.48	24.88	24.11
<i>Std. Dev.</i>	18.59	23.34	21.92	23.24	16.71	18.38	12.37

Table 1: A quantitative summary of the mesh resolution simulated

	<i>Mesh 1</i>	<i>Mesh 2</i>	<i>Mesh 3</i>	<i>Mesh 4</i>	<i>Mesh 5</i>	<i>Mesh 6</i>	<i>Mesh 7</i>
<i>Event 1</i>	37.94	42.87	50.35	53.85	54.04	55.66	52.93
<i>Event 2</i>	23.47	26.85	31.90	33.93	34.08	35.09	33.40
<i>Event 3</i>	14.70	17.67	20.28	21.13	21.20	21.75	20.76

Table 2: The effect of resolution on the peak output discharge ($m^3 s^{-1}$)

<i>Inundation depth (cm)</i>	<i>Mesh 1</i>	<i>Mesh 2</i>	<i>Mesh 3</i>	<i>Mesh 4</i>	<i>Mesh 5</i>	<i>Mesh 6</i>	<i>Mesh 7</i>
<i>25</i>	21.11	18.46	15.58	12.89	12.42	11.44	11.08
<i>10</i>	73.45	73.25	73.40	75.67	74.01	76.07	74.71
<i>5</i>	96.97	97.17	97.03	97.84	96.82	96.82	96.10

Table 3: The effect of resolution on the percentage of the domain inundated

The results obtained have indicated the importance of spatial resolution to the predictions obtained from numerical simulations. This is an important result as in a classical sense all the meshes used in the analyses fulfil the traditional criteria of flow length physics typically used to condition the choice of mesh resolution. Yet within this range of physically acceptable solution significant variation for the highest resolution mesh was noted. The results also indicated that:

- Spatial resolution directly affects bulk flow characteristics. For the meshes studied, as the element size decreases, bulk flow increases up to a point of the

penultimate mesh. The bulk flow characteristics for the highest resolution mesh, however, decrease.

- Spatial resolution directly affects inundation extent although it may be an effect of the loss of topographic information.
- Spatial resolution has a greater effect than the typical calibration parameter, friction, in altering the hydraulic simulations. This indicates that initial model set-up needs to be carefully considered and the transfer of parameter values should not occur.
- The spatial resolution has a dramatic effect on the internal results. Identification of systematic trends is not feasible owing to the complex nature of the system; however, the effect of the spatial resolution should always be considered.

Understanding the effects of mesh resolution in the development of a high resolution space/time model is clearly vital. Moreover, one of the advantages of the finite element technique is that the concentration of elements in a specific area can be increased if this region is believed to be sensitive. This needs to be reconsidered, as the same is true if an adaptive meshing technique is applied, where the topographic gradient determines the concentration of elements. If an area has a high concentration of elements (whether it is a subjective decision by the mesh user or has been created by the mesh generation procedure), then the simulated hydraulics (h , u and v) may be different in that area from what they would be if an equally weighted element size mesh had been created. This is demonstrated in the 15% variation of the scalar flow rate for a variation in mesh resolution. Although most hypotheses assume that the higher the spatial resolution the closer the simulated hydraulics are to the true solution, for field simulations there is currently no means of telling how close to the true solution the mesh actually is. It therefore appears that a complex feedback process operates within the modelling system driven by the spatial resolution of the mesh and has not previously been identified when applying distributed models to natural environments.

We can recommend that any future modelling projects, whether for this or other environmental problems, should construct at least four meshes of different spatial resolutions to ascertain the envelope of response to spatial resolution. This would enable the construction of boundaries for the mesh development, prior to more complex calibration processes. The transfer of such information, in the construction of a numerical algorithm relating spatial resolution to reach size in a more general sense, is not possible according to this initial study. However, further studies of this nature may provide an improved insight enabling a clearer definition of mesh/spatial boundaries to be achieved.